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*LABORATORY TEACHING OF LARGE CLASSES.**

TEACHING may be subdivided into two kinds: First, that which cultivates the faculties of the individual, increasing his ability to work for himself and enabling him to use his intellectual powers with confidence in the acquisition of knowledge. Second, that which disregards or takes for granted that he has these powers at his command and strives to increase his store of information. The first process is the improvement and building up of the intellectual forces by any means that will enable them to do their work thoroughly and correctly, and the second is practically, except in so far as it can be used in carrying on the first process, a load carried by the brain. Similar in fact, though not in kind, to the extra fats and extra growths, of all sorts carried by the body, it may sometimes be of advantage, and sometimes, when in unnatural proportion, a serious and perhaps even an injurious burden.

The cultivation of the original powers of the individual, of his whole mind, with, of course, proper regard for moral and physical well-being, which are, in my opinion, equally important and essential, is akin to the treatment by which a good teacher of athletics strives to improve the native strength of a pupil and give the muscles endurance and force, and which the young gymnast himself is taught how to use to the greatest advantage. This athletic training must go hand in hand with judicious feeding, and in the parallel processes of education similar objective training must go hand

*Annual discussion before the meeting of the American Society of Naturalists, Baltimore, December 27, 1894. The continuation of this discussion by Professors Bumpus and Ganong will be published in the next issue of SCIENCE.

in hand with a legitimate amount of information. It is striving against nature to throw a pupil wholly on his own resources and allow him to find his way alone. This effort not only wastes valuable time, but it is an attempt to return to primitive conditions and to produce unfavorable surroundings that do not exist at the present time. This kind of teaching is fortunately very rare nowadays, and usually an ideal that it is impossible to pursue consistently in actual practice.

The natural and right course is really followed by a very good teacher, and strives not only to exercise and train his pupil's faculties, but at the same time or at proper intervals furnishes information that will give needed nourishment and renewed strength to his power of doing pioneering work, if he be capable of this higher order of effort.

The happy combination of self-culture and sufficient intellectual meals is by no means easy, and they are mingled in due proportion only when the pupil can be employed for much the largest part of his time in the handling of objects or experiments under proper direction, which will enable him to build up by his own experience methods suitable for his own mind, or, failing that, to at least learn how original work has been done by others.

Laboratory teaching is an effort made now by all institutions to furnish proper facilities for practical instruction of this sort, and it is successful or the reverse, according to the proportions in which the system adopted deviates from the happy medium in which neither self-culture nor the administering of information is allowed to usurp the whole field.

This being a partial description of Laboratory teaching, it is a question in the minds of most naturalists whether it is in a strict sense applicable to large classes except under very exceptional conditions. In the first place, what is a large class; is it forty, eighty, or one hundred and sixty? Can the class be taken in sections or must it be handled as a whole? Can the instructor command laboratory facilities in the shape of rooms, tables, specimens or instruments, and materials for observation or experiment, and, above all, can he command assistants? All of these queries must be replied to in some shape by each instructor before it is possible for him to consider the subject from any practical point of view.

It is obvious that laboratory exercises and information must be individualized to be of the highest standard, and this could not be carried out fully by an instructor alone, except for a small class. There is also an obvious limitation of numbers due to the necessary limitation of facilities that can be offered by any institution, however well equipped. Even if an instructor had an enormous laboratory capable of accommodating a large class and money to employ the best of assistants, it is also obvious that the larger the class the further removed the members must be from personal contact with their teacher, and as individuals consequently less able to benefit by his experience and by his example, these two last being perhaps after all among the most important elements of good teaching.

Assistants come not only between the head teacher and his pupils, but where there are many minds there must be some strict system and set ways of doing the work, and more or less disregard of the peculiar needs of each individual. It is, however, evident that as long as this is recognized as a necessary evil, and the red tape of the system regarded in this light and not exalted into a fetish of productive virtue, a very large class may be kept at work through assistants, if they are allowed to have some individuality themselves and are taught to cultivate the same gift in some of their pupils. In such matters, however, one must speak

from the fulness of his own experience, and I must leave this subject to those who have had experience in conducting large laboratories crowded with pupils.

My own experience has been with a few, unfortunately with very few pupils of the highest grade, and then, skipping all intermediate grades, next with pupils who have come to me uninformed or worse off in being burdened with undigested information. The first of course had almost unlimited time and ample facilities, and, therefore, do not come into consideration here.

My classes have varied from ten to five hundred, but unluckily the binding force of the conditions under which instruction was given did not vary in the same proportion. I have always been obliged to give lessons to the whole class at once, and the time has been invariably limited to comparatively few hours.

Under these somewhat difficult conditions it became necessary to adopt some system that would include, as far as practicable at least, the idea of self culture, so that the pupils would at any rate not be led into the belief that they knew how to handle and use a subject when they really had only acquired some information and the power to read about it more intelligently, and perhaps also the ability to recognize certain facts of which no educated man should be ignorant.

Permit me to exercise one of the usual privileges of every speaker and enlarge somewhat the boundaries of this discussion by asking you to consider Laboratory Teaching as but one branch of object teaching. We shall then be able to regard it from the point of view of its essential character and see more clearly its application to cases in which large classes must be dealt with in lecture rooms capacious enough to hold from eighty to five hundred or even more persons. It may then be said, that in proportion as a lecturer follows objective methods and clings to the habit of making his audience see, each for himself or herself, the objects he is talking about, in just the same proportion is he trying, at least, to educate them according to the ideal standards.

Some twenty-four years ago the Teachers' School of Science was begun in Boston and it became necessary to decide how the lessons should be conducted. To be faithful to the ideals of science and handle a class as large as could be comfortably seated in the lecture room of the Boston Society of Natural History was the practical problem, and secondarily how to do this so as to lead to the final adoption of natural history teaching in the public schools.

Two necessary conditions were assumed as the basis of the system adopted: first, the actual study of specimens, and second, the subsequent possession of these by the teachers. This system was inaugurated with a class of eighty, and was found to be practicable with five hundred persons, and succeeded as well as could be expected with such large audiences. The lecturers employed by the school, which subsequently came for the most part under the patronage of the Trustee of the Lowell Institute, Mr. Augustus Lowell, were instructed to conform to the requirements mentioned above, and the system has not been materially altered since the beginning, except in one of these requirements. Of late years it has not been deemed necessary to have very large classes, nor to distribute specimens in such profusion as during the earlier years in which hundreds of thousands had been given away. The details are very simple. Every person in the audience is furnished with a certain number of specimens. These are placed by assistants upon temporary tables opposite each chair before the lesson begins. The tables for large classes were of the simplest description, mere boards with a slight moulding to keep objects from rolling off. They were made in sections and were fastened to the floor by iron stanch-

ions that could be unscrewed and removed after they were no longer needed. It occupied three men about one-half of a day to put them up and take them down and store them away from a lecture room accommodating five hundred persons. The seats in this room were the ordinary distance apart and were not constructed especially for the purpose of giving additional room for these tables. Similar tables have also been built and used successfully in several different lecture rooms.

The lecturer leads his hearers to observe with the specimens in hand certain facts, and he may if he chooses go far beyond these simple observations in his remarks, and he very often does this, but the specimens are dead weights upon his flights into the empyrean of fancy or theory. The objects are there; they demand constant attention, and the teacher cannot keep away from their consideration, nor can his audience lose consciousness that they are the subjects upon which the work is to be done.

The principal difficulty is to acquire the habit of carrying on the thread of the discourse, directing it to some definite morphologic point, or whatever the lecturer may choose, weaving the facts shown by the specimens into a demonstration of this point, and at the same time keep the pupils at work upon the specimens to such an extent that most of them actually see the needed facts.

The field capable of being illustrated and taught in this way is necessarily limited, and there are in each branch of science certain series of facts requiring elaborate apparatus or rare specimens that cannot be used in sufficient numbers. Nevertheless, the limits in each department are not so narrow as one at first thinks, and the field covered grows continually broader in proportion to the ability and experience of the instructor.

The first expense is not large; the cost of the Geological and Mineralogical specimens was about ten dollars for each lecture, and for Botany about fifteen, and Zoölogy twenty to twenty-five for audiences of five hundred.

But before entering upon the second part of my subject, the application of this method to smaller classes, permit me to say that diagrams were used in order to direct the attention of the audience to the facts to be observed, and they were encouraged to make notes and sketches and instructed in the use of a cheap magnifier costing from sixty to seventy-five cents. The lecturer was allowed also to place objects similar to those in the hands of the audience upon his table and platform and on the tables in the body of the lecture room, and whenever practicable these were living representatives of the preparation.

It is needless to say to this audience that no claim is made here to the discovery of a royal road to knowledge. The system itself is an ancient one and was used before I was born by many persons. The habit of observing accurately cannot be formed by an hour or two of work on Saturday afternoon, even with the use of specimens. The method has, however, a valid claim to consideration in so far as it possesses great advantages over the subjective methods of the ordinary lecture, when illustrated solely by diagrams or stereopticon pictures, and its results are far more satisfactory.

All lessons or lectures away from the actual presence of the objects described or discussed throw the individual back upon his own mental processes, unless he already has experience and knowledge of the facts treated. Illustrations in the shape of diagrams or stereopticon pictures are substitutes of one dimension; they have the superficial attributes of length and breadth, but their apparent thickness and solidity are artistic shams. People who are taught

in this way think afterwards in a weak subjective form. The objects depicted are present to them as pictures, not as things. The classes in drawing at the Lowell Institute were objectively taught and not permitted to draw from illustrations, but among the pupils there were often some that had had instruction according to this method. They were seated and placed so that no two persons got the same view of a cube mounted on a stand, in one of their lessons. Those that had had no training from copying flat illustrations tried to depict what they saw; those that had had this sort of training usually outlined the cube as they thought a cube ought to appear, giving it the conventional shape and aspect it had in their own minds. Whether seated on the floor or on chairs, or standing, in front or at one side, the cube almost invariably appeared on their sheets with the top side in perspective, whether they saw the top or did not see it from their station.

Able pupils carry away from our lessons much more than they can from lectures, however elaborately adorned with illustrations, and our results show that even the crudest efforts to observe facts with examples in hand lead often to a realization of the effectiveness of objective work and a desire for more culture in this direction.

These lectures to large audiences created gradually a demand for more precise and extensive instruction in some of our pupils, and this demand led to the giving of series of lessons on the same subjects to more limited numbers and extending over longer periods of time. These have lately taken the form of consecutive courses running through each winter for four years. We have just finished one on Geology, of this amount of time, about one hundred and thirty hours in all, and another in Botany, and have still another in Zoölogy and Paleontology, of about the same length, which will be finished this year.

In these classes numbering from thirty-six to forty-eight the lecturer treats the audience in much the same way as far as specimens are concerned, but having more time and more control over the pupils, he can do his work more effectually. Each person must have a note-book and magnifier; microscopes are furnished by the Society. The pupils are told that they must make notes, and must make sketches of the specimens. Those who state that they cannot draw are instructed to try and are shown that the quality of their drawing is not of so much importance as the employment of the eyes and mind in trying to draw the object before them. The act of trying to draw a specimen is not absolutely essential to the success of this method, but it is very helpful. It holds the pupil down to his work, keeps him constantly observing, and he soon learns to make approximately a good outline of the specimen, and then studies the details much more closely than he would otherwise do, if not making an effort to represent them on his sketch.

Different teachers have different ways of doing their work, but in general it may be said that those at present at work in the school follow this process more or less and also hold either examinations at stated intervals or have reviews in which the students are questioned with regard to what they have been studying and so on. One gentleman keeps a complete card catalogue of names and marks, so that he can follow accurately the exact course of each pupil back through the entire four years, and he holds no final examination, preferring to make his work perfect as he goes along.

Two of the teachers—there are only four in all—have constantly had the services of two assistants who helped to set out the specimens and clear the tables after the lessons were finished. These assistants were for the most part selected from the audience, and can generally be obtained in this way,

either as voluntary laborers or for a very moderate compensation. These persons, under the direction of the teacher, help him to supervise the note making and microscopical observations of the pupils and help them to see and discuss with them the facts that they observe. A large part of every lesson is passed in the description and discussion of observations made on the specimens. The pupils are also encouraged to work independently in making connected studies and collections out of doors, and to embody the results in reports and actual collections presented at the final examinations or at the close of the term.

Field work is also carried on in connection with the laboratory lectures in mineralogy and geology, and it is proposed to do the same when opportunity offers in other branches. One can judge in part of the ability and attainments of classes by the examination papers and their note-books kept through the term, and the results in this direction have been highly satisfactory. I have not had time to gather any of these evidences as I had intended to do, and I shall have to ask you to take my word for it that these were more than creditable. I have brought a few placards of the courses and of the questions for the final examinations in two of the courses, which I have exhibited for your inspection.

The persons attending these lessons were all adults and mostly teachers in the public schools, but the same method has been found to be equally successful with classes of the Institution of Technology and Boston University, and no difficulty has been experienced in handling them in this way beyond what is usual with such pupils. Pupils of the Teachers' School of Science have also applied the same method to large classes of young people of both sexes in the public schools, and by covering less ground at each lesson succeeded with them also.

In certain subjects, such as Physical Geography, Chemistry and Physics, and Physiology, and so on, this method has a necessarily more limited application than in the branches enumerated above, but even in these departments it has been more or less used, directly by selecting the few experiments that could be actually made by individuals in the audience, and indirectly by showing others on the platform that could be repeated by them with apparatus that they could make themselves, or purchase with very small outlay.

Permit me in conclusion to repeat that it has been thoroughly tested with such classes of persons of all ages as have been described, but it has not yet, as far as I know, been applied to large classes of students in any university. If it has been applied to such classes by any one their experience is probably known to some persons in the audience, and I shall be glad to hear what the results have been. I am aware that our experience will probably be of real value only to those who have to deal with classes having at their command a limited number of hours and but little chance for laboratory work outside of the hours devoted to the lessons. Nevertheless, there are many who now lecture with illustrations, diagrams and the stereopticon, to whom I would with all deference suggest the possibility of adding to these specimens distributed among their pupils. And I further make bold to recommend that those who make partial use of text-books, as aids for the pupils to study and recite from, drop a part of these requirements and allow their pupils to substitute actual work on specimens done inside or outside of the class-room, collections made by themselves and so on. I also crave their permission to suggest one feature of our examinations which you will see mentioned on the cards I have displayed. This consists in placing before each pupil a set of test specimens which he is required to place in proper sequence as regards their

mutual relations, to number, name, describe, and so on, in accordance with what he has been taught. I have myself a way of slipping into this set one object that the pupils have never seen, so far as I know their studies. The replies to this silent questioner frequently enable me to determine who are the best observers and most original thinkers, and very often point out clearly the difference between them and those who are merely the best students.

Whether this system is the best that can be devised or has only some praiseworthy feature, or is in reality but a poor substitute for a good one, I shall not pretend to decide. There are numbers of scientific teachers of great experience and learning present who have heard my arguments and must be our judges, but I think they will all indulgently agree that the teachers who have adopted and elaborated this method have tried to come as near to the ideals of objective work as the adverse circumstances of large classes and limited time would permit.

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BOSTON.

*ORIGINAL RESEARCH AND CREATIVE AUTHORSHIP THE ESSENCE OF UNIVERSITY TEACHING.**

THAT which is most characteristic of the present epoch in the history of man is undoubtedly the vast and beneficent growth of science. In things apart from science, other races at times long past may be compared to the most civilized people of to-day.

The lyric poetry of Sappho has never been equalled. The epic flavor of Homer, even after translation, comes down to us unsurpassed through the ages. Dante, the voice of six silent centuries, may wait six centuries more before his mediæval miracle of song finds its peer.

The Apollo Belvidere, the Venus of Milo, the Laocoön are the glory of antique, the despair of modern sculpture. To mention oratory to a schoolboy is to recall Demosthenes and Cicero, even if he has never pictured Cæsar, that greatest of the sons of men, quelling the mutinous soldiery by his first word, or with outstretched arm, in Egypt's palace window, holding enthralled his raging enemies, gaining precious moments, *time*, the only thing he needed to enable him to crush them under his dominant intellect.

There is no need for multiplying examples. The one thing that gives the present generation its predominance is science. The foremost factor in modern life is science. All criticisms of the scope of life, of the essence of education, made before science had taken its present place, or attempting to ignore its prominence, are obsolete, as are of necessity any systems of education founded on pre-scientific or anti-scientific conceptions.

Unfortunately there are still some people so dull, so envious, so unscientifiic, so stupid as to maintain that the highest aim of a university should be the *training* of young men and young women, where they use the word 'training' in its repressive, inhibitive sense. The most profound discoveries of modern science unite in replacing this old 'training' idea of education by one immeasurably higher, finer, nobler. We now know that the paramount aim of teaching at every stage, and preëminently of the final stage, at the university, should be to *help* the developing mind, the developing character, the developing personality. Judicious, delicate, sympathetic *help* is now the watchword. Even horses and dogs worth owning are no longer 'broken;' they are 'gentled.'

What has brought about this glorious change? *Science*, the greatest achievement of human life, the one thing that puts to-

* Inaugural Address by the President of the Texas Academy of Science, Dr. George Bruce Halsted, October 12, 1894.